

# Auralisation and Visualisation as Tools for Learning in Acoustics

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## Introduction

'Auralisation' is listening to physical phenomena. It has been one of the main research areas of Chalmers Room Acoustic Group but in this project, it is used in a rather simplified way as sound examples explaining or demonstrating acoustics. Visualisation, on the other hand, is achieved by displaying physical processes in the form of animation on the computer screen.

This report concerns a pedagogical project financed by the Council for the Renewal of Undergraduate Education. The aim of this project was the development of a library containing auralisation and visualisation examples in cooperation with students from our education program 'sound and vibration'. The library is intended for independent use by our students and as demonstrations during the lectures in different courses. The main task of the library is to motivate students to concentrate on understanding and to offer the students alternative ways of looking at 'How acoustics works'.

The project aimed to combine both the technical development and the pedagogic approach. It is based on the specific problems we experience in our teaching activities in acoustics. The general goal is to foster student learning by exposing them to different perspectives on the central phenomena we teach, which is one principle of teaching for learning as described by Marton and Booth<sup>1</sup>, and to set the phenomena in their own worlds of experience.

Acoustics is a discipline with a number of special features. Many students are interested in the subject, yet most have difficulty with the course. The acoustic properties in engineering products are not obviously a property which should be specified by the customer, and shown in drawings. Unfortunately the acoustic properties of a product are inherent to the design, and can not be improved or fixed at a later stage. The acoustician's responsibility is to ensure satisfactory acoustic performance to products where the design and construction is to a high degree determined by other engineers or architects.

In many cases the acoustic properties cannot be computed in a detailed manner because the numerical computations would be overwhelmingly time consuming and expensive or the needed input data are not known. It has been stated 'It is easier to construct a car which is faster than to design a car which is quieter.' However, the trained acoustician can very often make a good estimate based on simple calculations, but this demands a deep insight in the physics of the

problems. It is therefore important in an acoustics course for such knowledge to be communicated to students in engineering so that acoustical engineering becomes an integrated part of the education of mechanical engineers, civil engineers and architects.

## **Project aims**

Firstly, the *technical aim* was to develop a library of demonstration examples concerning acoustic phenomena. Secondly, the *pedagogical aim* was to adapt the library to the needs of the students. The supposed function of such a library is to motivate students to focus on understanding, to support their understanding by enabling them to take the additional and realistic visual and aural perspectives on acoustic phenomena and to motivate them to ask themselves questions about the material. In this way they will form their own picture of acoustics, consistent with the established knowledge. The final aim was *to evaluate* the effect of the library as a teaching tool, at the end and continuously during the development.

A basic assumption in this project was that student participation in the development process was necessary in order to achieve the goals. Thus a panel was established consisting of 4 to 5 students and a teacher. The function of the panel was:

- to direct the planning phase of the project - interviews were planned based on the students' own experience from typical learning situations;
- to take part in the development of examples in which the visualisation and auralisation are used; and
- to take an active part in the evaluation.

## **First phase of the project**

During spring 1994 we obtained financial support from RePU (Reference group for pedagogical development) at Chalmers University of Technology, to carry out a pilot study. The aim of the study was to give us a clearer picture of what students experience as puzzling or difficult in the subject matter of the course, and what is necessary in order to improve our way of teaching. In collaboration with Shirley Booth, the educational adviser at Chalmers, interviews with students from our other courses were carried out. The interviews were designed to obtain information about their background in mathematics, physics and acoustics and their ability to apply this knowledge to the new material learned during the courses in acoustics, as well as their approaches to studying and learning. The results of the project can be summarised as follows.

During autumn 1996 a student panel was established. During the project the panel members changed due to the fact that most of the students were in their final years. In the planning phase the aim of the project was discussed and a time schedule for the different steps in the project was determined. The library was evaluated in two ways, through interviews and by 'tests'. It was also decided in which hardware/software form the library should appear. The student panel agreed that the library have a simple appearance without distracting elements. There should be separate libraries for teachers to use in classroom situations and for students to use independently.

As a preliminary, it was decided to carry out a test of already existing parts of the library. The test addressed the following questions:

- What function did the demonstrations have for the students?
- Is the presentation of the visualisation examples well adapted to the students?
- What learning approaches do they foster?
- What fundamental understanding of acoustic phenomena is reached?

Students came to our department on three separate occasions and watched a total of nine different animations. We presented short stories containing questions. The nine questions were of a very general character aiming mainly at understanding. The students were asked to answer these questions before they watched the animations. After having seen demonstrations related to the questions they were asked to amend their previous answers. The results were analysed by three different people (i.e. a teacher, a PhD student and an undergraduate student) independently. A scale of 0-5 was used in the following categories:

- Correctness: Is the content reasonable (strict correctness is not important)?
- Understanding: Is a deep understanding of the physical phenomena demonstrated?
- 'Own view': Has the student developed a personal view of the phenomena?
- 'Teacher's view': Has the student adopted the teacher's view and language to describe the problem?
- Modifications: Does watching the animation modify the perspective?
- Physical approach: Does the student base his/her explanation on physics?
- Mathematical approach: Does the student use formulae for the explanation?
- Pictorial approach: Does the student use any kind of picture for the explanation?

The rating was checked and extreme discrepancies were discussed to avoid results due to a wrong interpretation of the different categories.

The results of these tests showed that, for some of the students there was a clear increase in understanding while other students showed minor changes. The correctness category followed a similar pattern. Students with a relatively good understanding before watching the animation, made only small changes in their explanation due to the animation.

The rating for each individual student concerning perspective and approach showed that most of the students used the teacher's point of view from the lectures rather than developing their own formulation of the problem. For most of the demonstrations the viewpoint was not modified. The mathematical approach had the lowest priority and the physical approach was most used. Even the pictorial approach was used less than the physical approach, however the use of the pictorial approach seemed to be correlated to the amount of modification after watching the animation.

Reading the answers from the students it becomes obvious that not all demonstrations had the same effect. Demonstrations describing phenomena where the understanding by the students was very low also gave poor improvement by the use of visualisation examples. As expected there is no guarantee that animations will increase the understanding of physical phenomena.

## **Second phase**

From the beginning we planned to produce two libraries, one for students and one for teachers to use. The work of the student panel mainly concerned the library for students. As a first step the students prepared a list with phenomena which should be included in the library. This list was discussed during meetings and completed. In a second step it was discussed how these phenomena should be expressed in visualisation or auralisation examples. Test examples were programmed and tested in the group. The programming was carried out by one of the students and a teacher. Based on these demands the library was implemented in *Authorware* on a standard PC. The use of standard PCs allow students to use the library at home or in computer rooms. All the demonstrations have similar layout and navigation similar to that experienced when using the Internet.

An evaluation of the library was carried out by a series of interviews with students having access to the library. The interviews focused on five central questions, which frequently appeared during the work of the student panel.

- Which learning method is preferred by the students?
- How do students visualize acoustic phenomena?
- How much information is needed to recognise the picture we offer?
- Is it possible to take over a picture or do we simply modify our own pictures?
- Does the animation help at all?

The interviews had test runs, which included evaluation of the interview process. Two groups of students were interviewed, students who took part in the previous test (7 students) and 10 students from an ongoing course in acoustics. During the evaluation we used two primary criteria for classification: goal and motivation for studies, and self confidence in mathematics and physics. The results from the interviews allow the students to be classified into groups.

### **Group 1**

These are students with high self-confidence in mathematics. Their response to the animations was very positive. It was clearly stated that the animations improved the picture students have concerning acoustics, that they obtained a clearer understanding from their point of view and that if this type of tool was available they would use it.

### **Group 2**

High or moderate motivation, their goal is to understand but they often fail due to a lack of time and confidence. There were some positive comments indicating that the animations helped understanding. However, the comments were mostly critical such as 'they might be skipped when time is short' or 'they were too simple, so they did not help much' or 'one needs help in the form of questions and answers'.

### **Group 3**

Moderate or low motivation, often only interested in passing the examination. Their attitude towards the library was rather indifferent. We obtained very little response and none of the students would use the library, unless the content is relevant for the examination. Explaining physical phenomena or expressions the students try to relate to courses and textbooks instead to develop their own explanations.

The results from the evaluation of the library's functional value can be summarised thus: While highly motivated students appreciated the library, less motivated students skipped the library for a variety of reasons. The library itself is not sufficient to motivate students. Instead we have to create an environment where the library is a relevant part of the teaching. This will be done by using the library frequently during lectures but also by increasing the focus on understanding. The students should be able to recognise contents of the library in the examination to make the library relevant even for students who normally would skip it.

Our intention has to be to create an environment which supports the learning process. The library might be a step in this direction, however successful teaching needs more than a tool but also a motivation for using these tools.

## Reference

1. Marton, F. and Booth, S. A., The learner's experience of learning, in D. Olson and N. Torrance (eds), *Handbook of Education and Human Development: New models of Learning, Teaching and Schooling*. Oxford: Blackwell (in press).

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